

# **Characterization of Humid-Forest and Savanna Ecoregions of West and Central Africa using Satellite Sensor Data of Three Eras**

## **Characterization of Eco Regions in Africa (CERA)**

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Project Web page:

[http://www.geology.yale.edu/~smith/africa\\_project.html](http://www.geology.yale.edu/~smith/africa_project.html)

<http://www.yale.edu/ceo/>

# **Characterization of Eco Regions in Africa (CERA)**

## **Eco Regions of study**

1. Sudan savanna (LGP: < 150 days);
2. Northern Guinea savanna (LGP: 151-180 days);
3. Southern Guinea savanna (LGP: 151-210 days);
4. Derived savanna (LGP : 211-270 days);
5. Degraded forest (LGP: > 270 days);
6. Forest margin (LGP: > 270 days); and
7. Primary forest (LGP: > 270 days).

LGP = length of growing period

# **Characterization of Eco Regions in Africa (CERA) OBJECTIVES**

The following Objectives will be achieved using satellite sensor data of 3 eras:

1. Agroforest characterization and carbon credits;
2. Regrowth dynamics or agricultural fallow systems;
3. Study major weeds and grasses (*Chromolenea odorata* and *Imperata cylindrica*);
4. Forest fragmentation and dynamics (e.g., logging, slash and burn, regrowth, species composition);
5. Land cover transformations over decades;
6. Degradation levels of natural environments: Characterize and evaluate; and
7. Carbon budgets for above ground biomass.

# **Characterization of Eco Regions in Africa (CERA) OBJECTIVES**

Specific Issues of focus:

1. Agricultural fallow systems and Regrowth dynamics;
2. Degradation levels of natural environments: Characterize and evaluate;
3. Agricultural intensification and related components (croplands, rangelands, and useful trees);
4. Land cover change dynamics over decades;
5. Agroforest characterization and carbon credits;
6. Forest and savanna fragmentation and dynamics (e.g., logging, slash and burn, regrowth, species composition);

Final goal .....Carbon budgets from above ground biomass.....in distinct ecoregions.

# **Characterization of Eco Regions in Africa (CERA) Satellite Sensor Data of 3 Eras**

1. pre-1999 era (e.g., TM, MSS, JERS SAR);
2. Earth Observing System (EOS) era (e.g., ETM+, ASTER, IKONOS-2); and
3. New Millennium Program era (e.g., Hyperion, ALI).

Note: Plus hyperspectral data from hand held or platform mounted spectroradiometer data.

Hyperspatial (e.g., IKONOS) and Hyperspectral (e.g., Hyperion) data open a New Era in remote sensing. How does the data from these sensors compare with sensors of previous eras?

# **Characterization of Eco Regions in Africa (CERA) Ground Truth Data**

Data gathered at each 30 by 30 meter (or 15 by 15 meter) plots include

- Species: tree, shrub, grass, weed species
- dbh of trees and shrubs of > 10 cm. Diameter
- Tree height
- Land cover classes and their percentage
- Land use
- Spectroradiometer data in 350 to 2500 nanometers (for regrowth fallows, grasses, weeds, shrubs, agricultural crops)
- Photos (digital and slide)
- GPS location

Note: Total of 677 plots. 332 plots from Nigeria and Benin (year 2000); 67 plots from Cameroon (year 2000); 76 plots from Central African Republic (year 2000); 202 plots from Cameroon (year 1995)

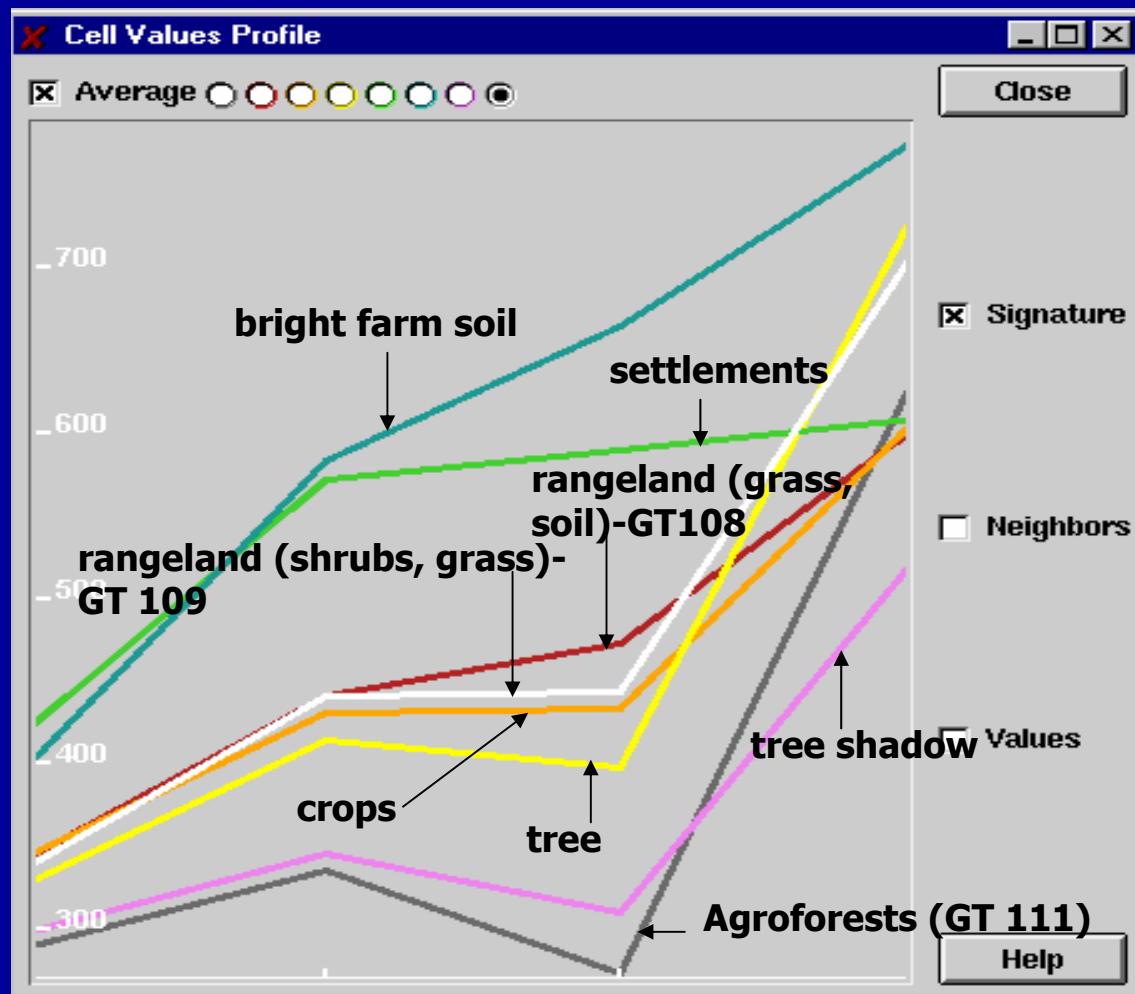
# **Characterization of Eco Regions in Africa (CERA) Datasets**

1. Satellite sensor data from 3 eras;
2. Hyperspectral data from spectroradiometer;
3. Ground truth data from field surveys;

Note: Specific focus on hyperspatial data from IKONOS.

# Characterization of Eco Regions in Africa (CERA) Spectral Profile of Distinct Classes in an IKONOS Image

Badume bechi, sudan savanna



# Rangelands and Plantations

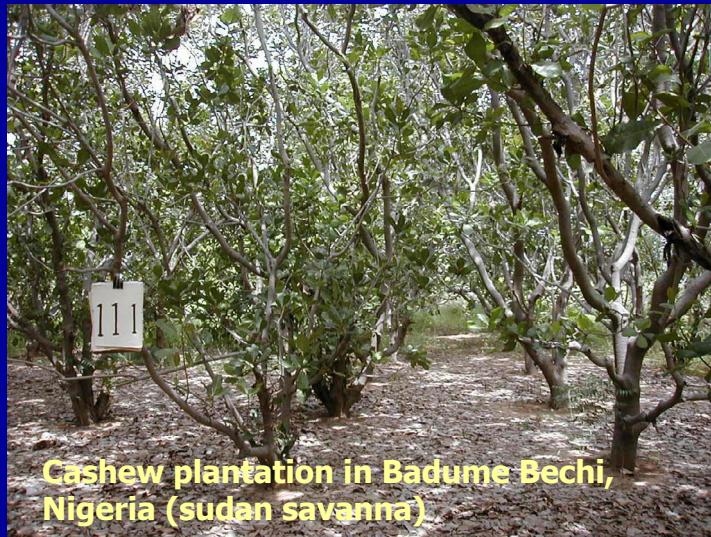
Sudan Savanna, Badume Bechi, Nigeria



Rangelands with low biomass in  
Badume Bechi, Nigeria (sudan savanna)



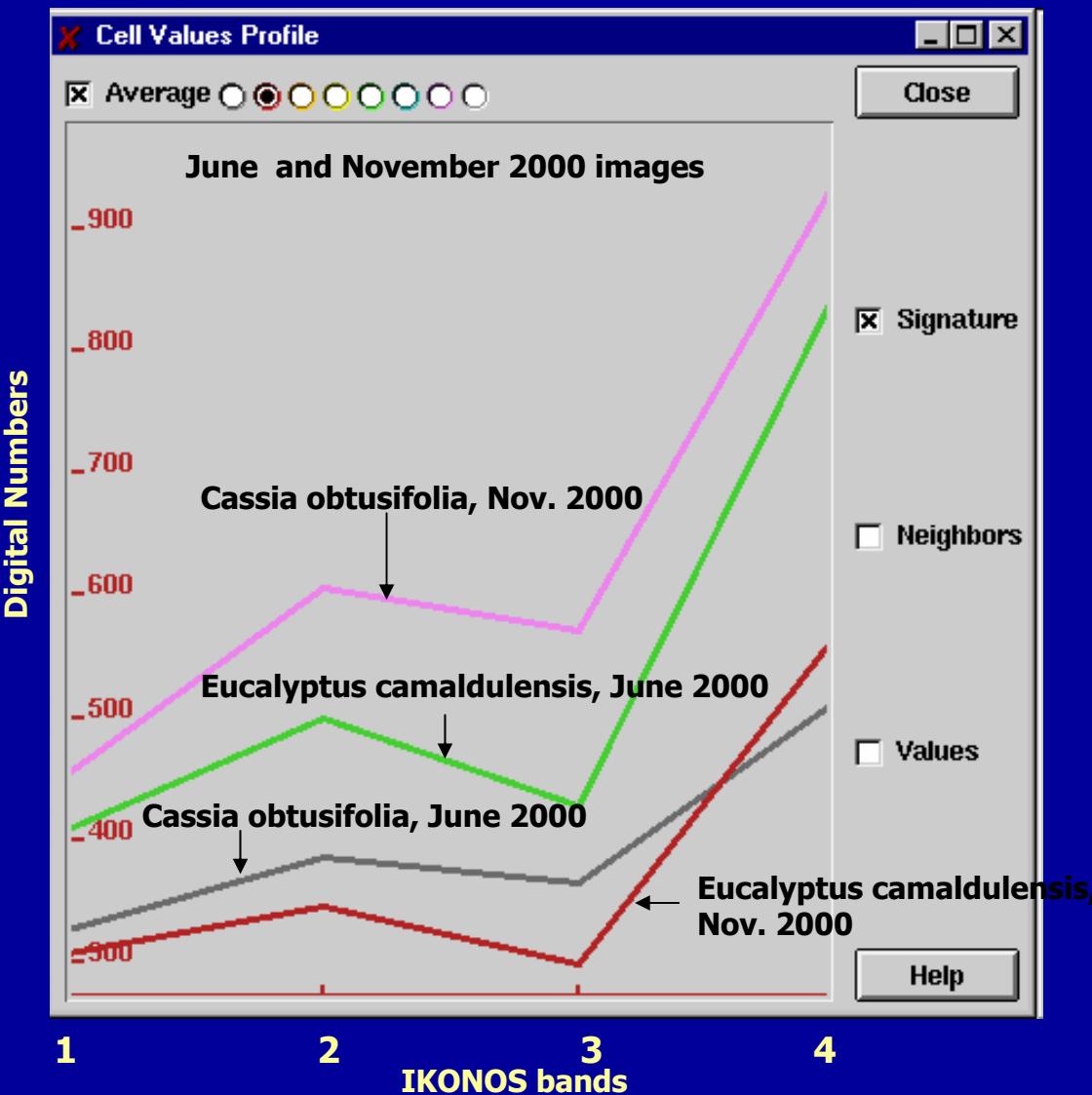
Rangelands with denser biomass in  
Badume Bechi, Nigeria (sudan savanna)



Cashew plantation in Badume Bechi,  
Nigeria (sudan savanna)

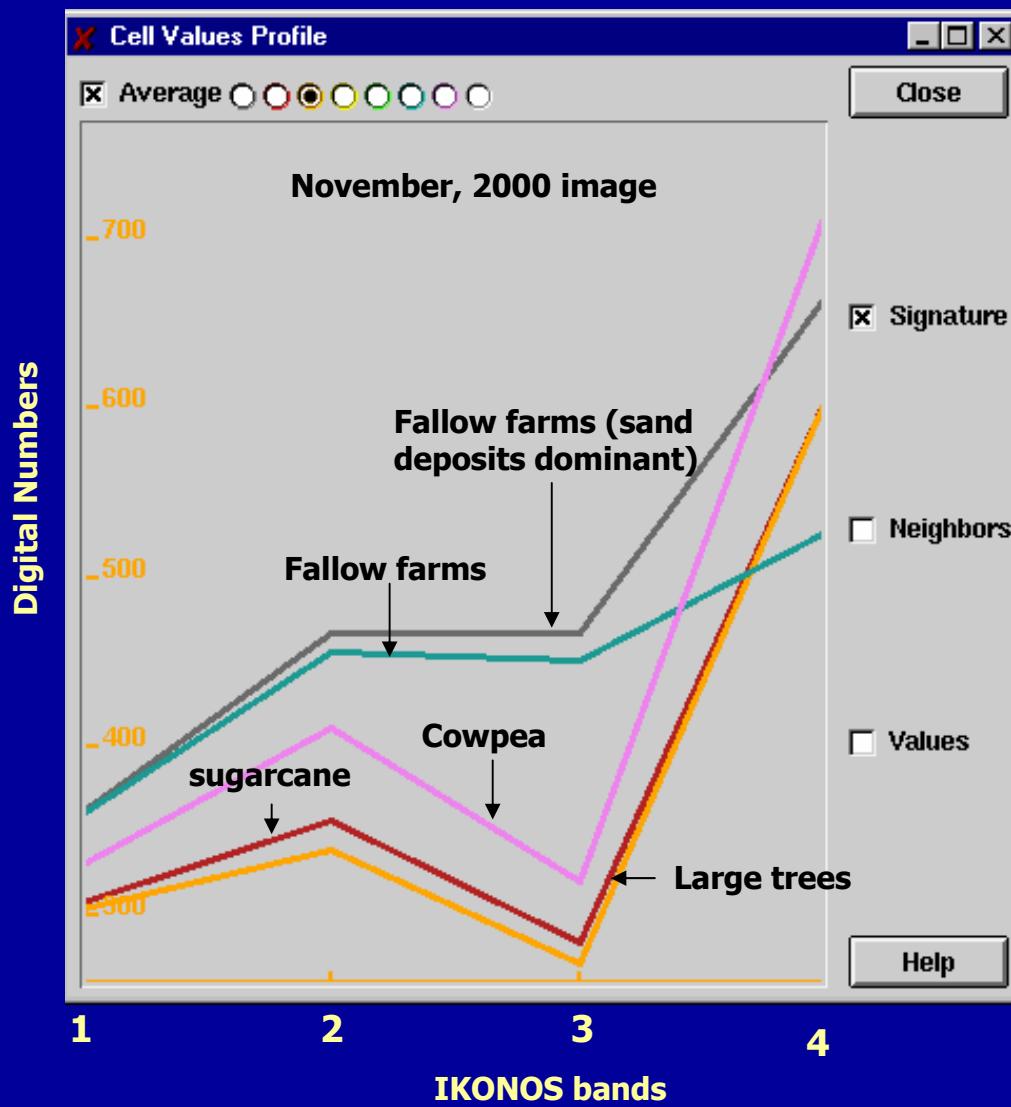
# Temporal Spectral Profiles of Land Cover Classes in an IKONOS Image

Danayamaka, Nigeria in N. Guinea savanna



# Temporal Spectral Profiles of Agricultural Crops in an IKONOS Image

Danayamaka, Nigeria in N. Guinea savanna



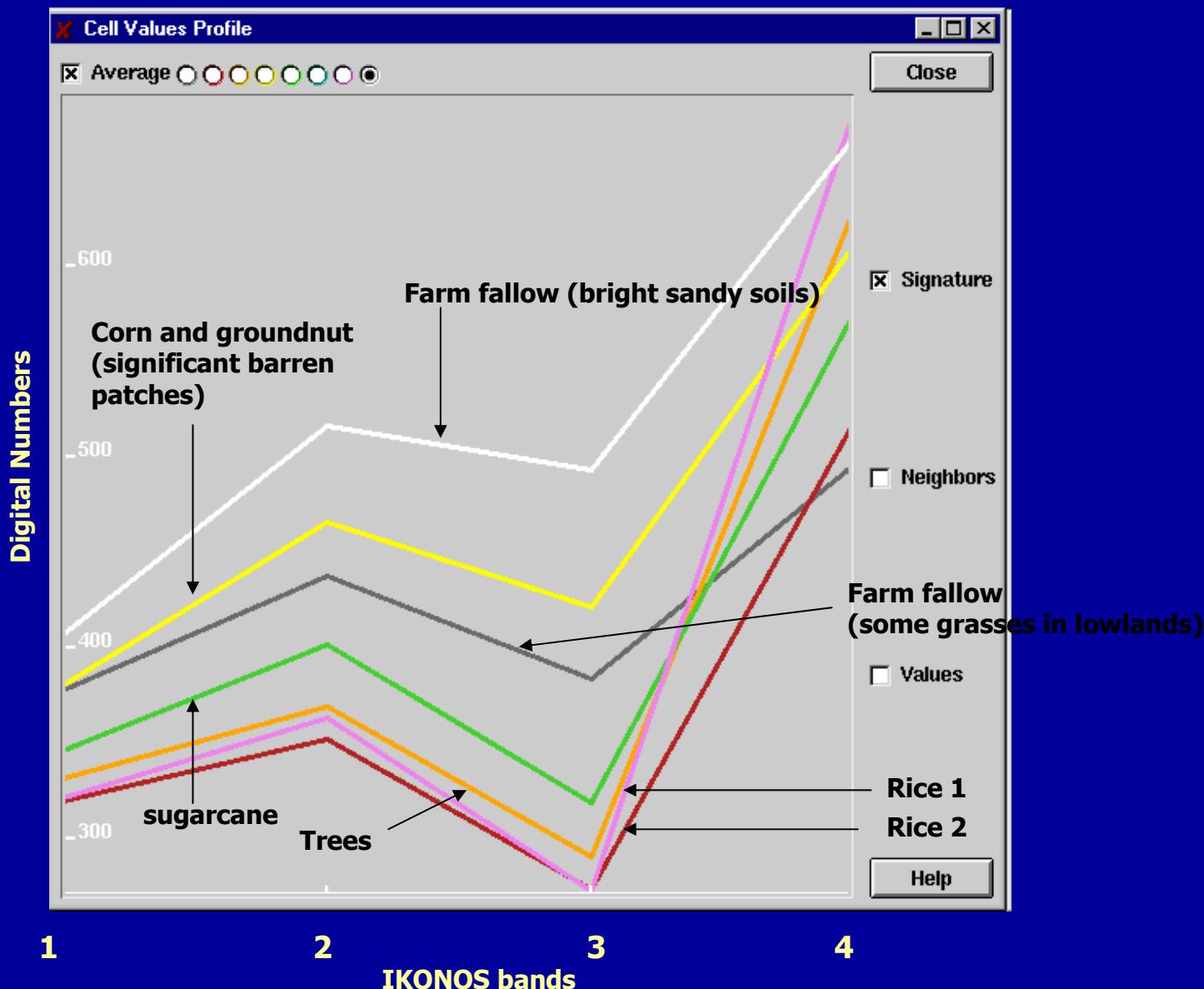
# Legumes, Crops, and Plantations

N. Guinea savanna, Danayamaka, Nigeria



# Spectral Profiles of Agricultural Crops in an IKONOS Image

Kaswan Magani, Nigeria in N. Guinea savanna



# Lowland and Upland Crops

N. Guinea savanna, Kaswan Magani, Nigeria



Lowland: Sugarcane crop in Kaswan magani, Nigeria (N. Guinea savanna)



Lowland: Rice crop in Kaswan Magani, Nigeria (N. Guinea savanna)



Upland: Corn crop in Kaswan Magani, Nigeria (N. Guinea savanna)

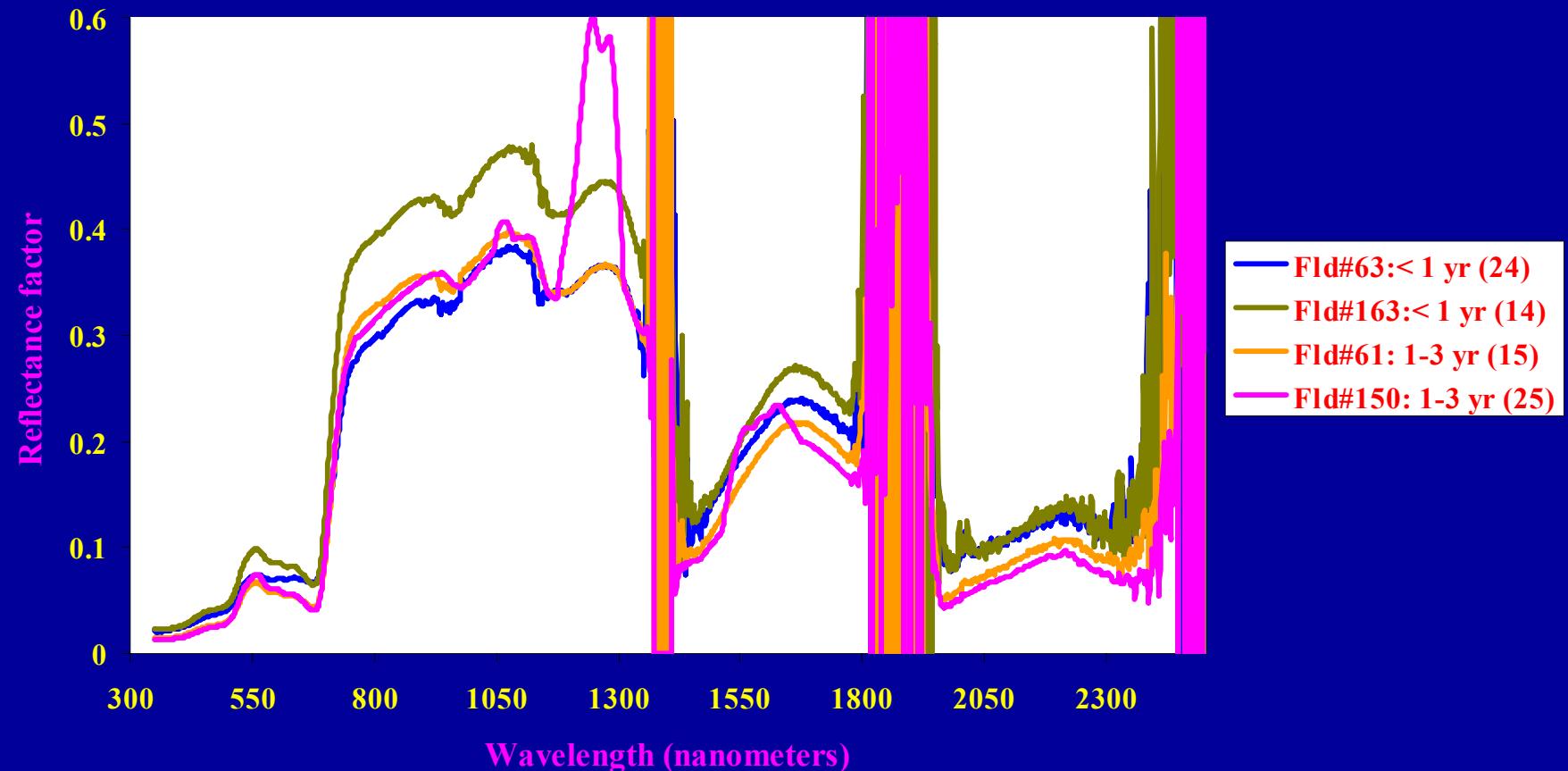


Upland: Groundnut and corn crops in Kaswan magani, Nigeria (N. Guinea savanna)

# Hyperspectral Data Characteristics for Agricultural Fallows

African savannas  
(Northern and Southern)

Regrowth or Agricultural fallows



# Agricultural Fallows or Regrowth Dynamics

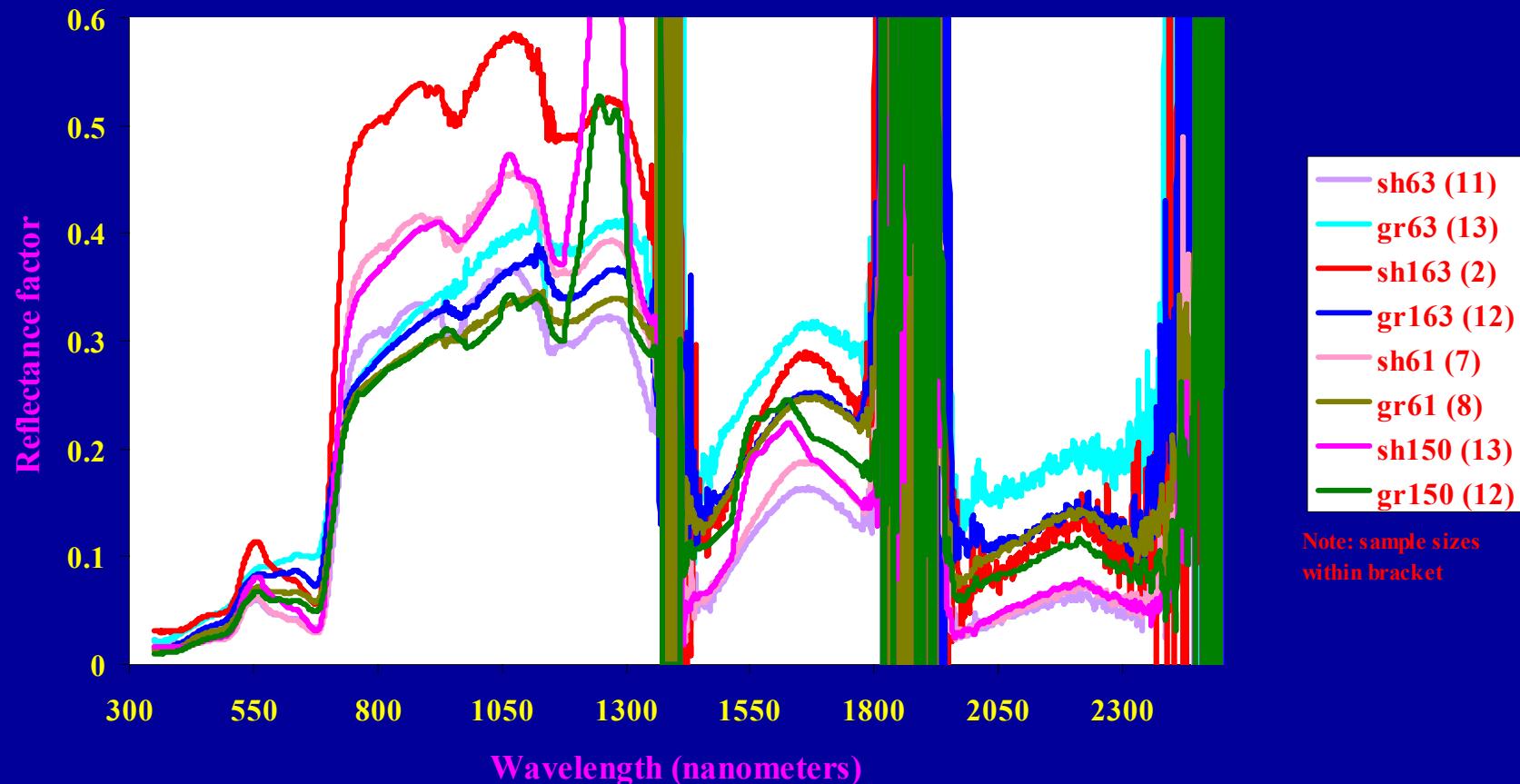
N. Guinea savanna, Kaswan Magani, Nigeria



# Hyperspectral Data Characteristics for Agricultural Fallows

African savannas  
(Northern and Southern)

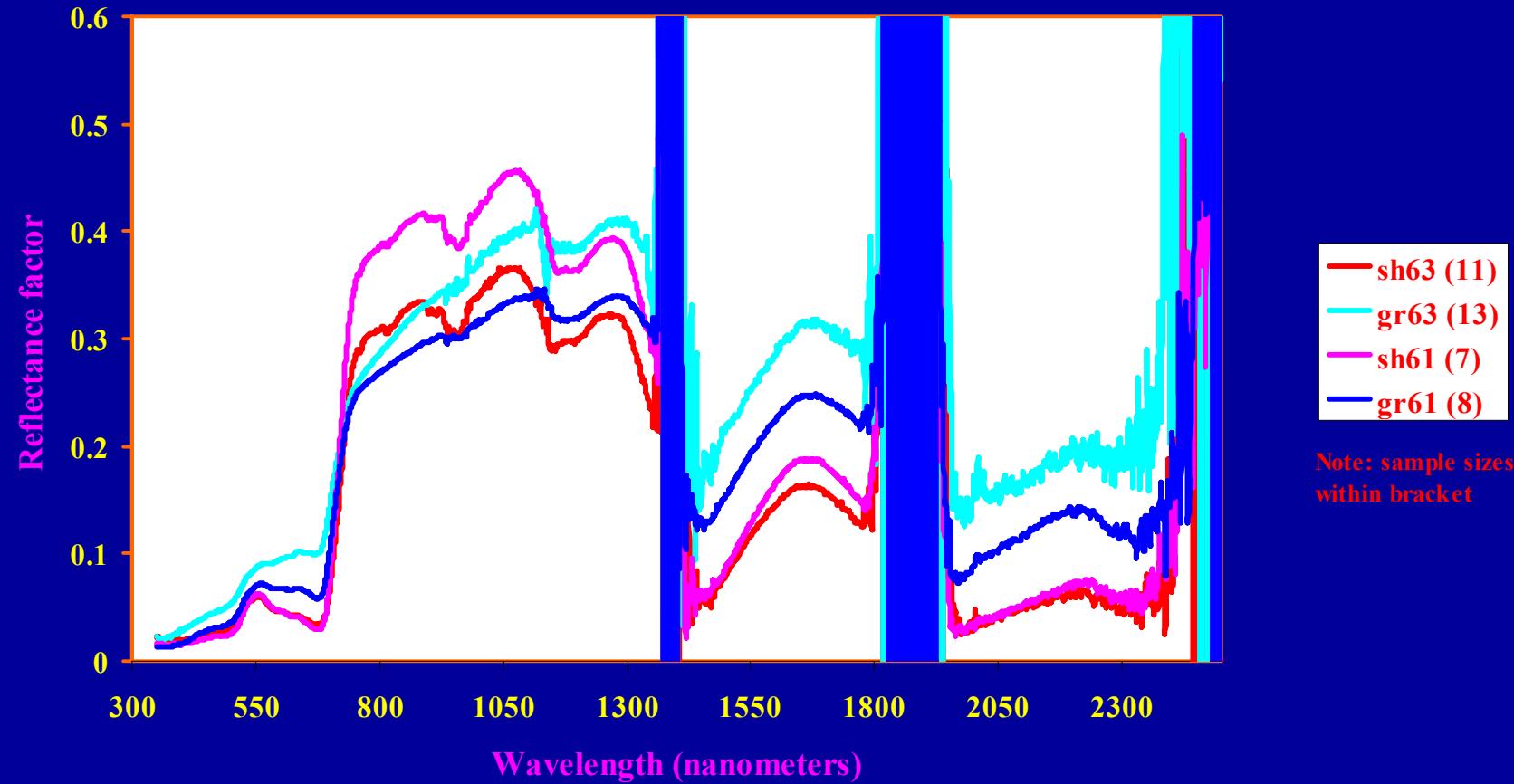
Shrubs and grasses in Agricultural fallows



# Hyperspectral Data Characteristics for Agricultural Fallows

Northern Guinea savanna

Shrubs and grasses in Agricultural fallows



# Agricultural Fallows or Regrowth Dynamic

N. Guinea savanna, Kaswan Magani, Nigeria



Fld#63; < 1 yr fallow in Kaswan Magani,  
Nigeria (N. Guinea savanna)

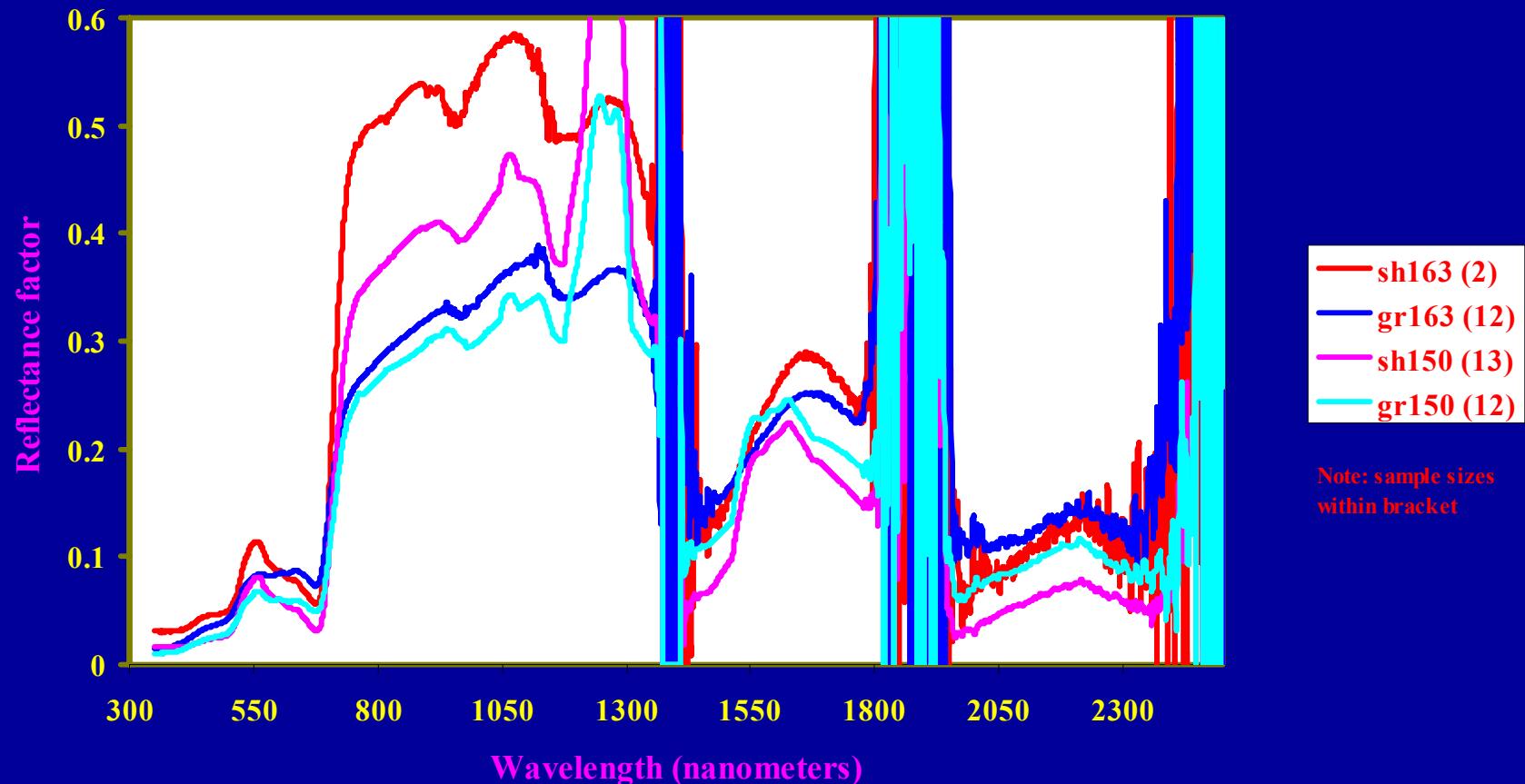


Fld#61; 1-3 yr fallow in Kaswan Magani,  
Nigeria (N. Guinea savanna)

# Hyperspectral Data Characteristics for Agricultural Fallows

Southern Guinea Savanna

Shrubs and grasses in Agricultural fallows



# Agricultural Fallows or Regrowth Dynamics

S. Guinea savanna, South of Niger River (Near Mokwa), Nigeria



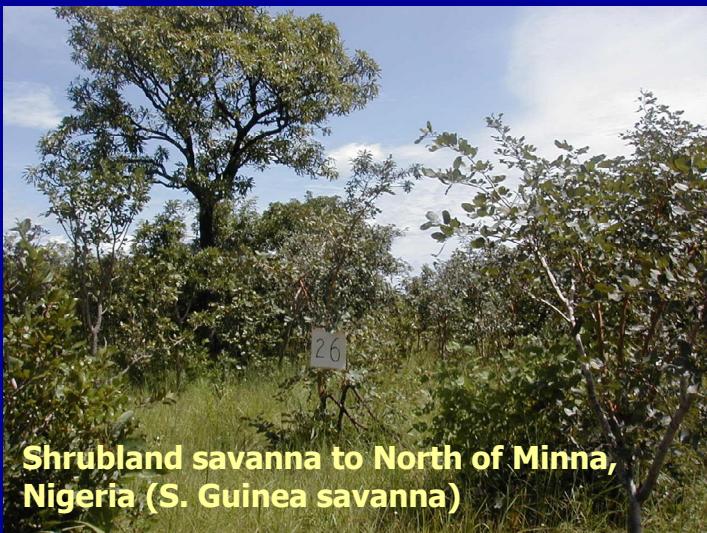
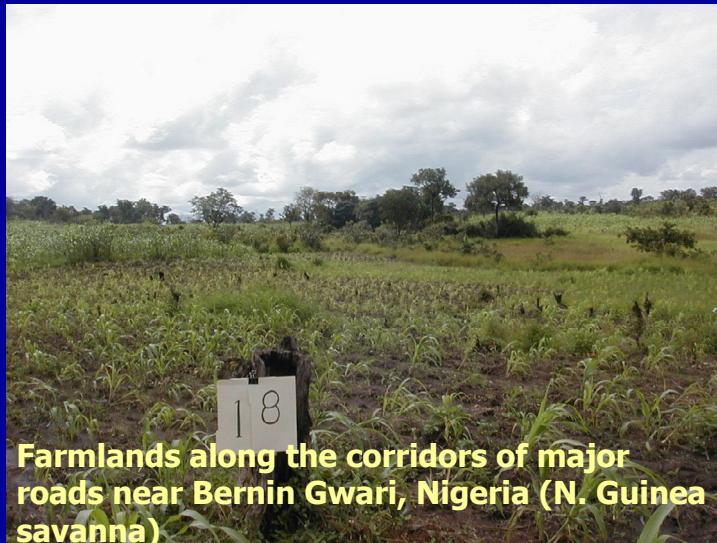
Fld#163; < 1 yr fallow South of Niger river  
near Mokwa, Nigeria ( S. Guinea savanna)

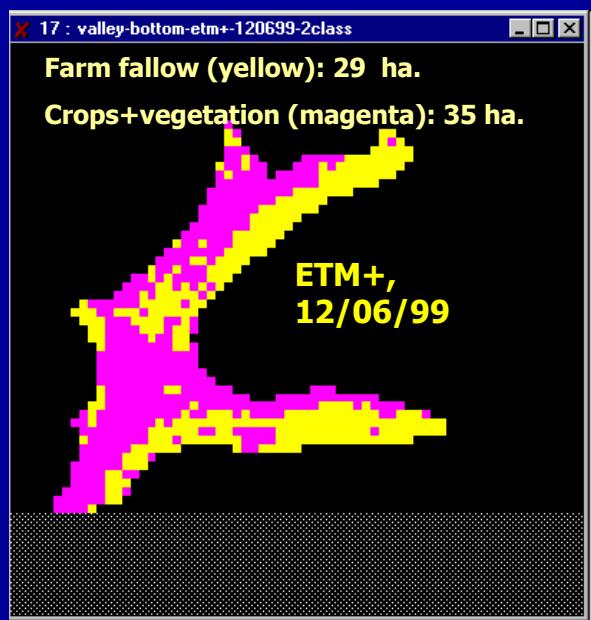
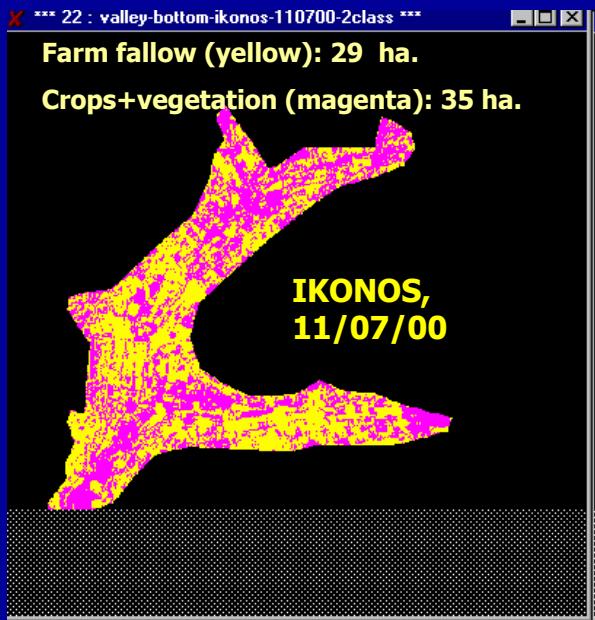


Fld#150; 1-3 yr fallow South of Niger river  
near Mokwa, Nigeria (S. Guinea savanna)

# Savanna Woodlands, Agriculture, and Regrowth (Fallows)

## N. Guinea savanna and S. Guinea Savanna

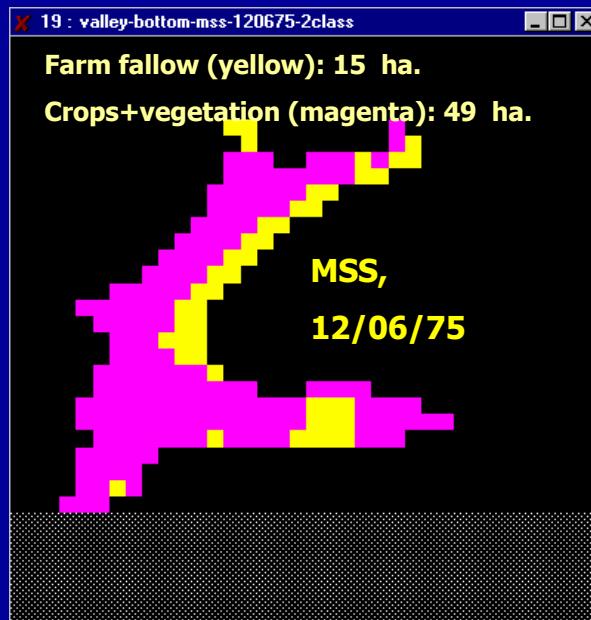
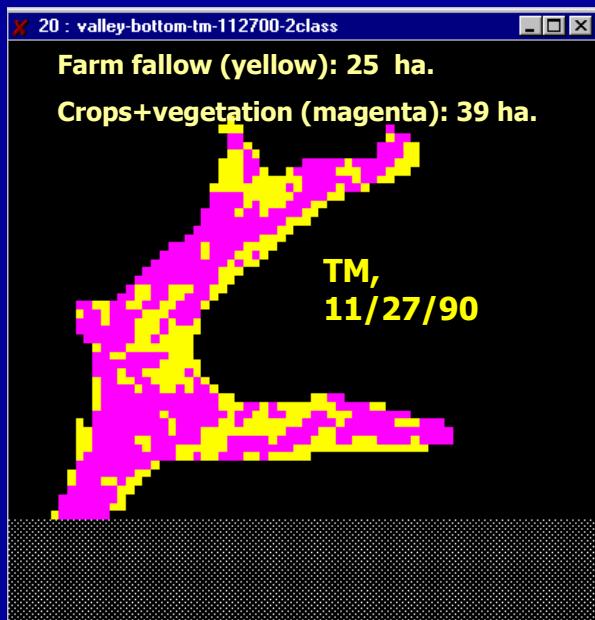




Temporal change in land use using multiple satellite sensor data over 3 decades

In a valley bottom of N. Guinea savanna

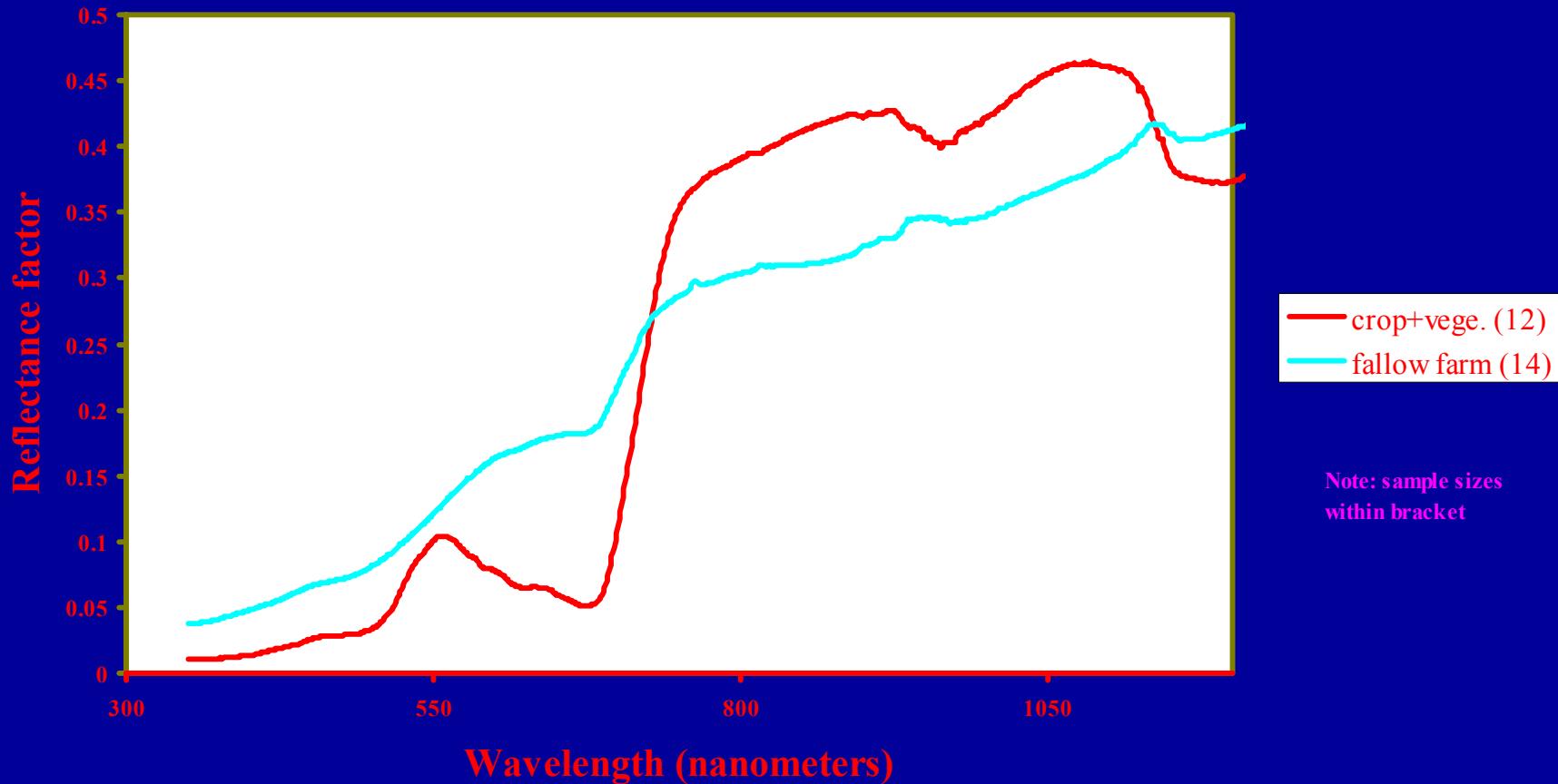
Note: detail provided by IKONOS compared to other images



# Hyperspectral Data

N. Guinea savanna, Kaswan Magani, Nigeria

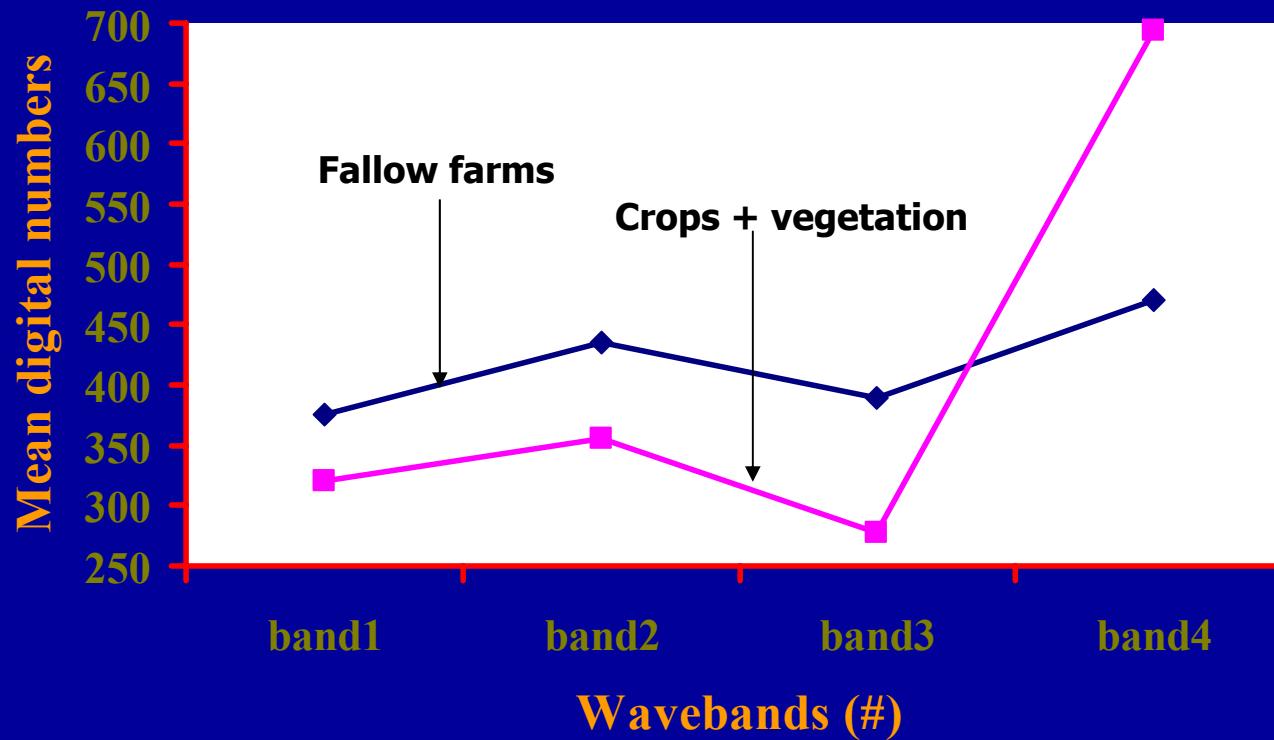
Fallow farms vs. crops and natural vegetation



# Spectral Profile from IKONOS Image

N. Guinea savanna, Kaswan Magani, Nigeria

## Fallow farms vs. Crops + vegetation



# Degradation of Savanna Woodlands

N. Guinea savanna and S. Guinea Savanna



Firewood for nearby towns



Firewood for nearby towns



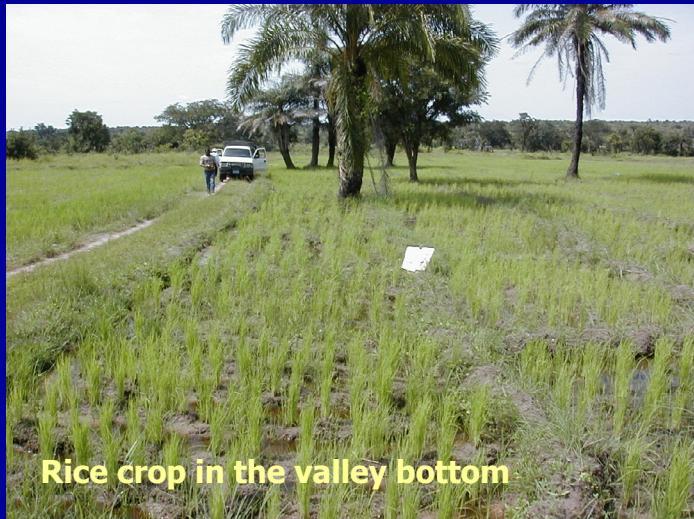
Logged savanna woodlands



Logged savanna woodlands

# Land Cover Along a Toposequence

S. Guinea savanna, Bida, Nigeria



Rice crop in the valley bottom



Corn crop in valley fringes



1-3 year fallow in valley fringes



Savanna shrubland in uplands

# **Oil Palm Plantations, Agriculture, Scattered Trees, and Carbon Credits**

**Derived savannas, Zouzouyou, Benin**



**Oil palm plantation (closely spaced)**



**Oil palm (young) and cassava crop**



**Soybeans, orange trees, and a large tree**



**Imperata cylindrica**

# **Oil Palm Plantations, Carbon Sequestration, and Riparian Forest**

**Derived savannas, Southern Benin**



**Oil palm plantations**



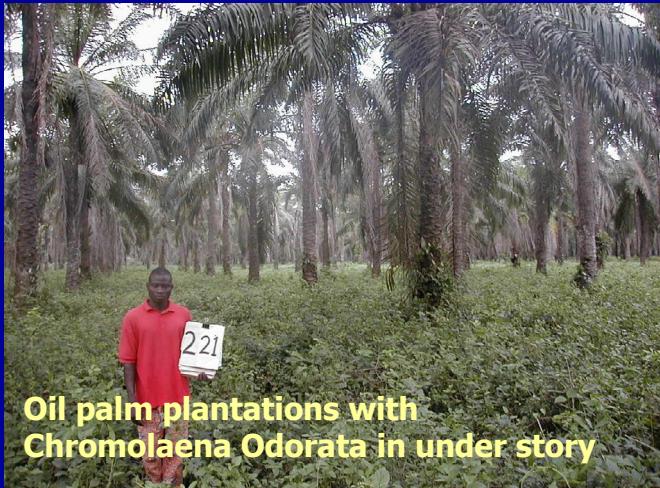
**Oil palm plantations with  
Chromolaena Odorata in under story**

## **Oil Palm Structure and Size**

**1. Well spaced out trees (9 to 10 m apart).**

**2. Chromolaena Odorata weed as under canopy.**

**3. Very large size (few hundred Hectares).**



**Oil palm plantations with  
Chromolaena Odorata in under story**



**Lowland riparian forest with  
bamboo**

# Humid Forests

Bayanga, Central African Republic



Lowland humid forests- measuring dbh



Lowland humid forests-GPS location data

# Humid Forests

Bayanga, Central African Republic



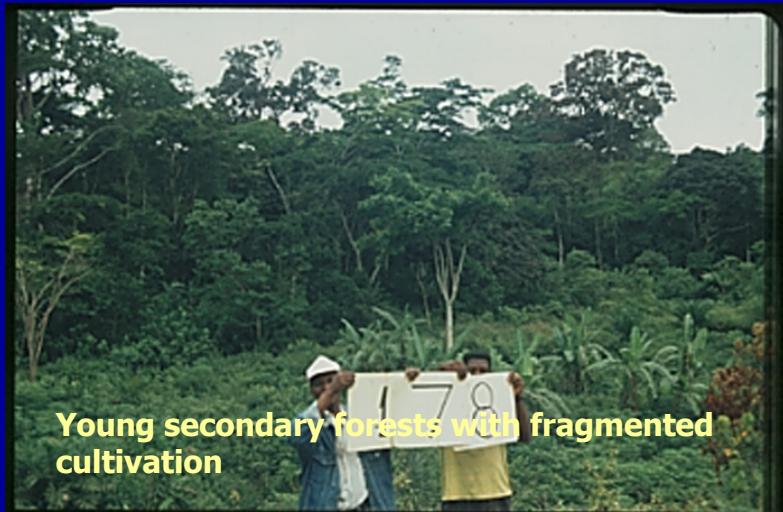
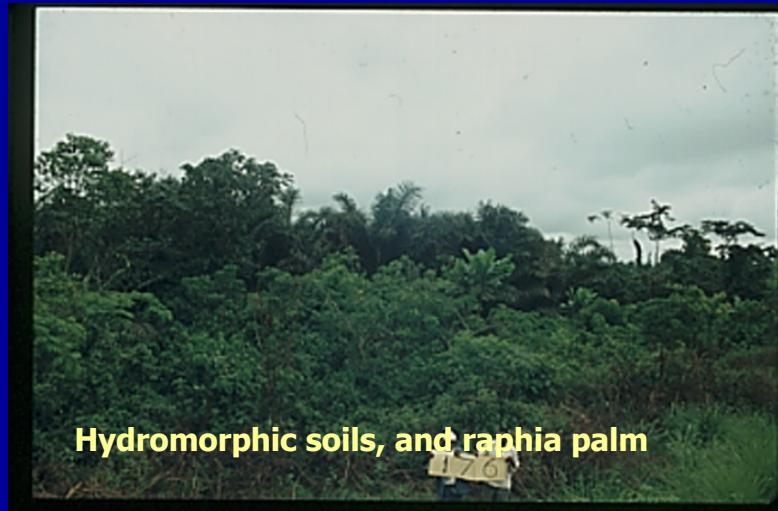
Humid forest gaps, senescing



Upland humid forests; gathering GPS

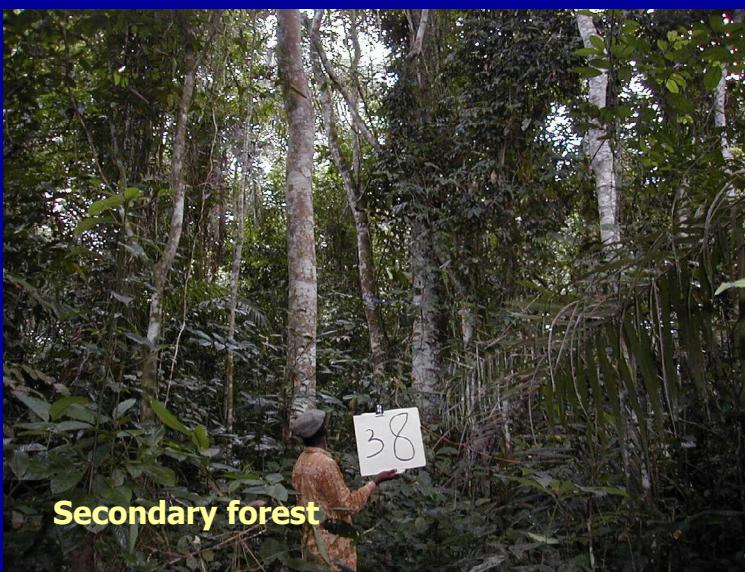
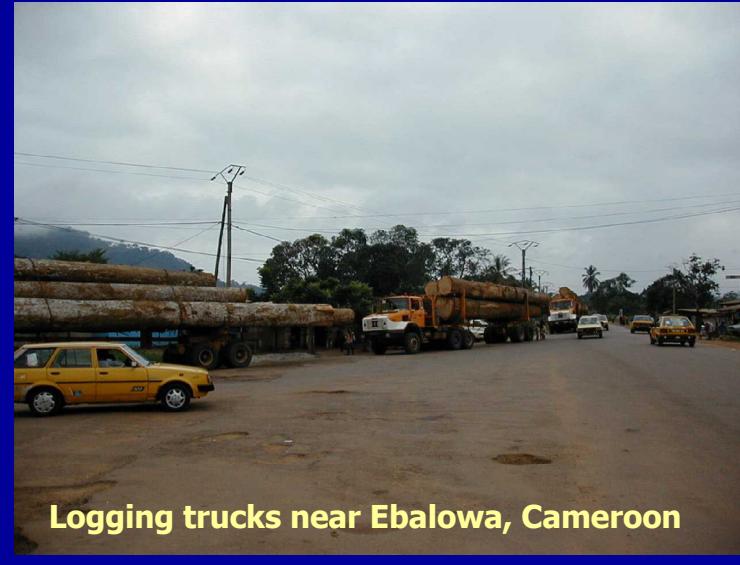
# Shifting Cultivation, Forest Fragmentation, and Secondary Forests

Forest margins, Near Yaounde, Cameroon



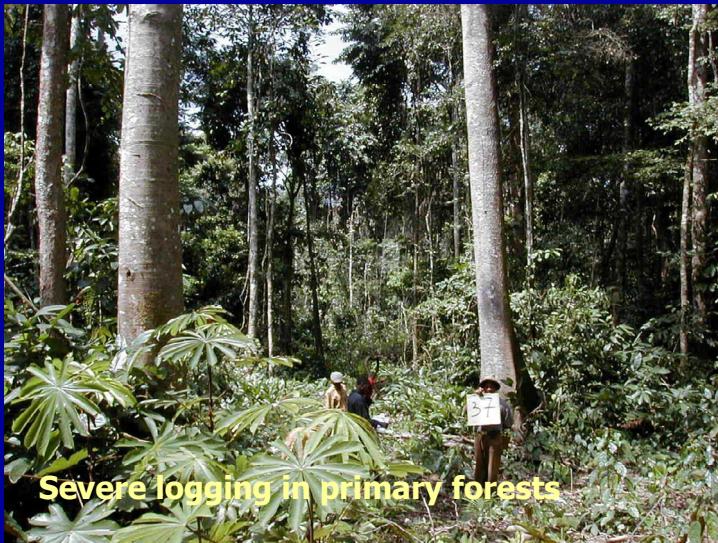
# Humid Forests and Logging

Forest margins, Yaounde-Ebalowa, Cameroon



# Primary Forests and Logging

Forest margins, Yaounde-Ebalowa, Cameroon



Severe logging in primary forests



Severe logging in primary forests



Relatively intact primary forests



Logging roads

# Ground Truth Teams

Nigeria, Benin, and Cameroon



Ground truth team in Nigeria



Dinner in Mokwa, Nigeria



In S. Guinea savanna, Nigeria



Ground truth team in Cameroon

# Shifting Cultivation, Forest Fragmentation, and Secondary Forests

Forest margins, Near Yaounde, Cameroon



Young secondary forests with fragmented cultivation

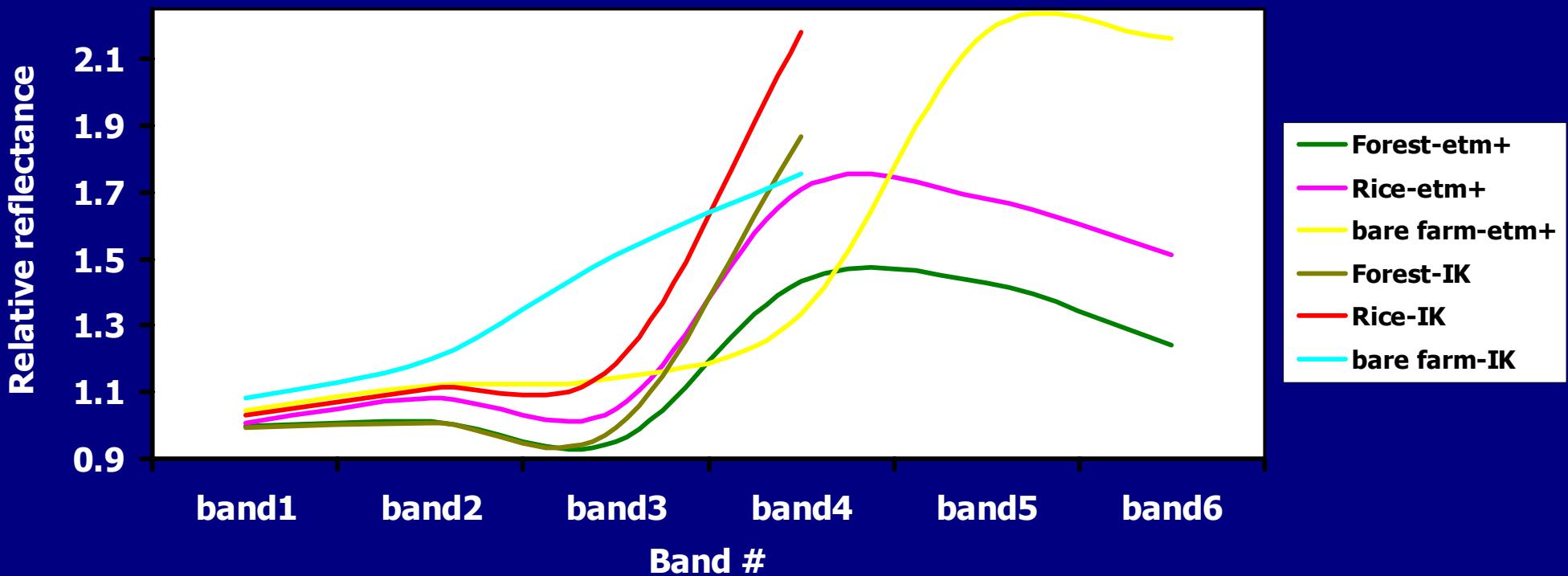


Mature secondary forests with fragmentation

# IKONOS (Dec. 13, 2000) vs. Landsat ETM+ (Feb. 06, 2000)

Derived savanna, IITA, Ibadan, Nigeria

## Magnitude of Reflectance in Wavebands for Land Cover Types **relative to** reflectance in deep water



# **Characterization of Eco Regions in Africa (CERA)**

## **Concluding Thoughts**

### **Hyperspatial IKONOS Data**

1. New applications: savanna tree density, individual trees in savannas, detail road-network including foot pathways;
2. Components of Landscape: can be studied in great detail (e.g., biomass levels in rangelands, fallow systems like N fixation legumes, plantations like eucalyptus);
3. Agroforests and Carbon credits: makes it feasible delineate and study agroforests (e.g., oil palm) and teak plantations for assessing biomass that could lead to determining carbon budgets;
4. Precise within farm information: specifically when farm sizes are small. Farm size and shape, and variability within individual farms.

....and potential for many New levels of Information (e.g., what do 2 distinct types of rainforest tree crowns tell us?).....are currently investigated.

# Characterization of Eco Regions in Africa (CERA)

## Concluding Thoughts

### Hyperspectral (e.g., Spectroradiometer) Data

1. **Agricultural fallows or regrowth dynamics:** it is possible to distinguish between various stages of regrowth fallows (e.g., < 1 year, 1-3 year) using hyperspectral data;
2. **Characteristics of individual components of landscape:** spectral delineation of individual components of landscape (e.g., grasses, shrubs) shows promise;
3. **Hypotheses 1:** indications are that the various levels of regrowth are best distinguished using specific narrow portions of the spectrum that need to be established;
4. **Hypotheses 2:** individual components of landscape (e.g., grasses, shrubs, certain species types such as Chromolaena orodata and Imperata cylindrica) can be best characterized using high spectral resolution data.